

APACHE TRIBE OF OKLAHOMA HOUSING AUTHORITY TRIP REPORT

Assessment of Mold and Moisture Conditions

Final Report

Date:
March 8-9, 2005

Prepared for:
U.S. Department of Housing & Urban Development
Office of Native American Programs

Prepared by:
UIUC/Building Research Council
One East St. Mary's Road
Champaign, IL 61820

Under sub-contract to:
Magna Systems, Inc.
340 E. Second Street, Suite 409
Los Angeles, CA 90012-4249
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PART I

APACHE TRIBE OF OKLAHOMA HOUSING AUTHORITY TRIP REPORT

INTRODUCTION

Paul Francisco from the Building Research Council of the University of Illinois at Urbana-Champaign and Eugene Goldfarb from Magna Systems, Inc., accompanied by Elton Jones, from HUD's Eastern Woodlands Office of Native American Programs, conducted a site visit at the Apache Tribe of Oklahoma Housing Authority (ATOHA) on March 8-9, 2005. ATOHA administers the housing program for the Apache Tribe of Oklahoma and is located in Anadarko, Oklahoma. The site visit provided technical assistance to ATOHA in assessing mold and moisture conditions in housing units. This report summarizes activities and issues addressed while on site. A detailed analysis of findings and recommendations is found in *PART II: Apache Tribe of Oklahoma Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes in Anadarko, Oklahoma*.

BACKGROUND INFORMATION

Anadarko, Oklahoma, home to the Apache Tribe of Oklahoma, is located approximately sixty miles southwest of Oklahoma City in Caddo County, an area of 1,278.3 square miles that gets between 28 to 32 inches of rainfall a year. The population of Caddo County is 30,150, with a little over one quarter of American Indian ancestry. According to Mr. Martin Bitseedy of the ATOHA, the office oversees approximately 300 homes, of which about 100 are Low Rent and the rest are Mutual Help.

The assessment team responded to a request from the Eastern Woodlands Office of Native American Programs to assess site and housing conditions contributing to mold and moisture problems at the Apache Tribe of Oklahoma. The Executive Director of ATOHA requested technical assistance to address mold and moisture conditions.

The assessment team visited five existing and one newly constructed home. All were slab on grade but included a wide variety of construction types, including conventional stick built, SIPS (Structural Insulated Panels) and an experimental Styrofoam-stucco home. The new home was part of a townhouse, whereas the older homes were all single-family residences. The homes ranged in age from newly constructed to 10 years old.

Day 1: Monday, March 7, 2005

Monday was a travel day.

Day 2: Tuesday, March 8, 2005

The assessment team arrived at the Office of ATOHA in Anadarko, Oklahoma on Tuesday morning. The team met with Mr. Martin Bitseedy to discuss the day's activities, outline the team's role while on site, and address ATOHA concerns regarding the site visit.

ATOHA selected the properties to be inspected and Mr. Bitseedy coordinated the logistics for the site visit. Following the meeting, the assessment team inspected five homes with reported mold problems (two low-rent and three Mutual Help) and then inspected a newly constructed home to view current construction practices. The assessment team was accompanied by Mr. Bitseedy, Charles Beaver, Lottie Jay, and Gary Bishop to some or all inspected sites.

Digital photographs were taken to record conditions in all homes. The inspection process also involved visual assessments of both interior and exterior conditions; qualitative assessments of exhaust fan airflow; and discussions with available residents. *PART II: Apache Tribe of Oklahoma Technical Housing Authority Housing Assessment Report: Examining Mold and Moisture Conditions of Homes in Anadarko, Oklahoma* provides a detailed analysis of findings and recommendations for the homes investigated.

Day 3: Wednesday, March 9, 2004

On Wednesday afternoon debriefing and training was provided from approximately 1:00 PM to 3:30 PM to the following members of ATOHA:

Martin Bitseedy	Housing Authority
Gary Bishop	Housing Development
Lottie Jay	HDS Housing Resident Counselor
Charles Beaver	Property Maintenance Manager
Hammond Motah	Apache Tribe Housing
Karen L Perva	Apache Tribe Housing
Donna A. Hinsely	Apache Tribe Housing
Michelle Whitewolf	Apache Tribe Housing
Howard Palmer	Fire/Safety Coordinator

The remainder of Wednesday was spent on travel.

FINDINGS

The findings listed below are specific to the five inspected homes and may not cover all issues that the ATOHA manages in other homes. ATOHA may reference these findings and subsequent recommendations when similar moisture problems are encountered in other homes.

Stormwater Management

1. Most homes had limited or no gutters and rainwater was routinely allowed to pond and stand alongside the homes.
2. The ponding resulted not only from the limited gutter systems but also from the lack of positive drainage away from the homes. In some homes there were depressions in the soil inside the drip lines where water had run off the roof.
3. Flashing and siding were not always installed, leaving paths for stormwater to penetrate the structures.
4. Consistent with not maintaining the imperviousness of the outer skin of the homes, the stucco on an older Styrofoam based home had deteriorated, allowing significant water penetration. If the foam in the walls of this home contacted the ground, this would be an additional mechanism for water to enter the home.
5. Some potential openings along expansion joints were not completely sealed.

Bathroom and Kitchen Ventilation

Several homes had inadequate ventilation or improperly exhausted ventilation, which can lead to elevated interior moisture levels:

1. Ducts routinely vented to gables and not to the outside.
2. Some fans were not ducted at all, but vented directly to the attic.
3. Most kitchens had recirculating fans, which do not remove any moisture.
4. Duct tape should never be used to seal ducts (use duct mastic or butyl-backed metal tape).
5. Vents should be smooth metal ductwork with a minimum of bends and the shortest length necessary.
6. Existing bathroom fans should be replaced with low-sone models and controlled by timers so that they continue to operate for at least 20 minutes after use of the bathroom.

Condensation

Condensation can concentrate sufficient moisture to promote mold growth. Although moisture removal with proper ventilation will eliminate most condensation, we noted the following conditions that unnecessarily facilitated condensation:

1. Use of thick material for drapes.
2. Use of metal-frame windows. Metal frames are highly conductive and are often sufficiently cold enough to allow moisture to condense.
3. Possible condensation (or rainwater) on combustion air intake.
4. A potential thermal bridge in the Styrofoam home (where an incompletely sealed void would allow cold air in and conduct the cold to the interior surface).

Maintenance and Quality Control

Part of moisture control requires attention to details that prevent moisture from entering the home. We noted the following items that either were never installed or had not been maintained:

1. Missing flashing and/or siding.
2. Missing attic access hatch cover.
3. Stucco deterioration.
4. Missing exhaust ducts.
5. Apparent plumbing leak.

It is important that residents notify ATOHA immediately regarding moisture and mold problems and that these concerns be promptly investigated. An easily fixed untreated leak can quickly turn into a complicated, expensive mold problem.

Exterior Conditions

We noted the following additional problems on the exterior of the home:

1. One home apparently had either a leaking wastewater pipe or leaking hose bib pipe at the back of the home. This leak caused water to enter the bedroom on the other side of the wall, causing mold and moisture problems.
2. Dirt was allowed to accumulate on the vinyl siding. While vinyl is not a food source for mold, dirt is, and the dirt on the siding resulted in mold growth on the siding.

Health and Safety

Although not directly related to mold and moisture problems we noted one home where a garage was being converted into a bedroom. We advise ATOHA to carefully monitor

this situation. For that home, we recommend installation of low volume ventilation of no greater than about 20 CFM and a carbon monoxide detector in proximity to the utility closet.

MOLD TESTING

The assessment team generally recommends that if there is mold inside a building, it needs to be cleaned up. It is not necessary to identify the species of mold growing in a residence, since there is no baseline of acceptable or unacceptable mold concentrations in a home. This message is consistent with other federal agencies and experts as documented below.

The Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section (BAIHS EHSS), *Guidelines on Assessment and Remediation of Fungi in Indoor Environments* position on testing is:

Consistent with Center for Disease Control (CDC) and Environmental Protection Agency, BAIHS EHSS does not recommend testing as the first response to an indoor air quality concern. Instead, careful detailed visual inspection and recognition of moldy odors should be used to find problems needing correction. Efforts should focus on areas where there are signs of moisture or high humidity or where moisture problems are suspected. The investigation goals should be to locate indoor mold growth to determine how to correct the moisture problem and remove contamination safely and effectively.

The Adverse Human Health Effects Associated with Molds in the Indoor Environment: American College of Occupational and Environmental Medicine, states that to successfully remediate mold and moisture conditions, the water and moisture sources must be identified and corrected.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishing provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors, there is an inappropriate source of water and moisture that must be identified and corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in home, school, or office environment.

BAIHS EHSS Guidelines on Assessment and Remediation of Fungi in Indoor Environments discusses the limitations of testing:

Mold testing only provides a snapshot estimate for a single point in time and a single location. How well the test represents other locations and times is uncertain since the amounts and types of mold in the environment are always changing. Furthermore, there is no basis for setting a baseline of acceptable or unacceptable mold concentrations. The variability can be especially large for airborne molds, with significant changes occurring over the course of hours or less. Caution must also be used in interpreting surface testing results, since mold growth or deposition may not be uniform over an area and may increase or decrease as time passes. Unless many samples are taken over a period of time and the investigator has been mindful of building operations and activities during the testing, the results might not be very representative of typical conditions; in addition, tests reflecting typical conditions may also miss evidence of problems that only occur infrequently (water leaks during rain storms).

Mold testing is often expensive. If testing is unnecessary or done poorly, the money will not be available for remediation and repairs. The following web sites and references provide further information on mold remediation and testing.

Indoor Air Quality

Ball State University Indoor Environment Notebook - General resource on a number of topics related to indoor air quality.

http://publish.bsu.edu/ien/archives/archive_list.htm (will open a new browser window)

Mold

EPA - Mold Remediation in Schools and Commercial Buildings

<http://www.epa.gov/iaq/molds/index.html> (will open a new browser window)

New York City Department of Health Bureau of Environmental & Occupational Disease Epidemiology- Guidelines on Assessment and Remediation of Fungi in Indoor Environments

<http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html> (will open a new browser window)

References

Guidelines on Assessment and Remediation of Fungi in Indoor Environments. Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section

The Measurement Problem Regarding Mold, by William B. Rose, Research Architect, Building Research Council/School of Architecture, University of Illinois, Urbana-Champaign Campus, 2003.

Adverse Human Health Effects Associated with Mold in the Indoor Environment:

Position Statement by Hardin, Kelman, and Saxon, American College of Occupational and Environmental Medicine, 2002.

FUTURE HOUSING AUTHORITY ACTIONS

ATOHA was helpful during our site visit. The staff and residents were friendly and eager to resolve the mold situation. It was apparent that substantial work had been done at some of these homes to improve water control, including installation of porches and building up of patios. ATOHA seems to maintain a close partnership with the residents.

ATOHA should continue to strengthen the partnership between residents and itself, should educate occupants on minor maintenance and equipment use issues, and should address appropriate installation and construction techniques with maintenance staff. Problems relating to plumbing or resident use (such as disconnected dryers, not using bathroom ventilation) may result in elevated interior moisture levels. Therefore, communication between ATOHA staff and residents is essential.

Giving occupants the skills and knowledge to maintain, utilize, and repair the home will improve the relationship between the ATOHA and residents as well as improve indoor moisture conditions. Prompt attention to water and/or moisture issues, resulting from maintenance incidences, is important. It is not just enough to repair the leak. Maintenance staff should also insure that saturated parts of the building have dried.

In the inspected new construction, the primary recommendation for improved practice is to provide better exhaust ventilation, primarily in the kitchen. No kitchen ventilation had been installed. For the bathroom, we speculated that the exhaust fan vented only to the attic since the fans at other homes were installed in that manner; however, we were unable to inspect the fan vent directly.

PROGRAMMATIC RECOMMENDATIONS

A particular challenge to all housing authorities is the development of a prompt and effective service delivery system to address mold and moisture conditions. This requires a partnership between the housing authority and residents with a system that includes training for the maintenance staff on how to implement the technical recommendations and training for residents on their roles and responsibilities as homeowners and tenants. ATOHA has already taken action steps to create a partnership. Additional steps to supplement their program could include formalized methods for addressing mold problems and maintenance issues as they occur. For example:

1. Mandatory attendance at annual homeowner/tenant clinics as part of the annual recertification process. At these clinics, provide instruction on home maintenance issues, such as identifying and repairing leaks, checking for disconnected dryer vents, etc.

2. During the annual recertification process, ask occupants to complete a survey based on Housing Quality Standards (HQS) with additional questions on mold and moisture conditions in their homes. Completing the survey further engages residents in their own home maintenance. Furthermore, the survey responses provide additional information to the housing authority on unreported problems, especially leaks and inoperable fans that might contribute to an unsafe, unhealthy home environment.

A supplemental program could be implemented for maintenance staff. Mandatory meetings will educate personnel on regular maintenance issues, appropriate installation methods, and suitable construction practices to reduce moisture and prevent mold and mildew.

PART II

APACHE TRIBE OF OKLAHOMA HOUSING AUTHORITY

TECHNICAL HOUSING ASSESSMENT REPORT

**EXAMINING MOLD AND MOISTURE CONDITIONS IN HOMES ON APACHE
TRIBE OF OKLAHOMA PROPERTIES**

Executive Summary

Introduction

Section 1: Methodology

Section 2: Oklahoma Apache Housing Authority House Descriptions

Section 3: Findings

Section 4: Technical Recommendations

Section 5: Discussion of Common Problems

Appendix A: Housing Survey Summary Site Visit Report

Appendix B: Housing Assessment Results

EXECUTIVE SUMMARY

Five existing homes were inspected for mold and moisture problems for the Oklahoma Apache Housing Authority (ATOHA) located in Anadarko, Oklahoma. In addition, one home under construction was inspected in order to ascertain if current construction practices were in accordance with healthy homes practice. Paul Francisco from Building Research Council of the University of Illinois at Urbana-Champaign, and Eugene Goldfarb from Magna Systems, Inc., conducted the investigation on March 8 - 9, 2005 accompanied by ATOHA staff Mr. Martin Bitseedy, Charles Beaver, Lottie Jay, Gary Bishop, and Elton Jones from HUD's Eastern Woodlands Office of Native American Programs.

Exterior and interior inspections were conducted for the six homes. The inspection process involved visual assessment of both interior and exterior conditions, qualitative assessment of the airflow of bathroom exhaust fans, and resident interviews.

The relatively minor complaints include:

- Mold in bathrooms
- Window condensation
- Mold on siding
- Mold on floors (rugs), walls and baseboards

Interior mold was found in three inspected homes. The problem in two homes can be addressed with relatively modest measures. The third home, an "experimental" Styrofoam-stucco structure, poses a more difficult dilemma. The assessment team could not assess two primary features of this home that determine the course of comprehensive repair strategy:

1. What provides the structural support?
2. How do the walls connect to the foundation?

If the structural support is provided by a sheathing external to the foam, it may be possible to attach new siding over the existing finish and to the sheathing. If the structure is via concrete internal to the foam the above repair is not an option.

The foam should not contact the ground. In addition, exposed slab should be at the base of the exterior walls. The stucco sheathing extended all the way to the ground at the time of assessment, so any contact between the foam and ground could not be determined. Removal of the lower portion of the stucco should identify the detailing. If the foam extends to the ground, this would be a likely source of the water that caused the mold at the base of the walls inside the home. If the foam extends to the ground, and the foam is attached to an external sheathing, it may be possible to remove the lower portion of the foam to prevent the ground contact and to expose the slab.

Although almost any problem can be solved, the relevant question is usually whether the solution is cost effective. The current state of disrepair in this home dictates the need to determine the detailing of the home and identify areas with water damage, replace damaged sections, and then perform extensive work to provide a long-term solution to the exterior of the home. Simply patching the cracks in the stucco will almost certainly lead to new occurrences of cracking, because the current cracks provide a measure of stress relief that would be removed by patching. Therefore, consider a different exterior, even if that exterior is attached over the existing stucco. ATOHA should carefully analyze these costs versus the benefits before undertaking the suggested extensive repairs.

Only five of the approximately 300 homes managed by ATOHA were inspected. The findings listed below are specific to the homes inspected and may not cover all issues in homes managed by ATOHA. Reference these findings and subsequent recommendations when similar moisture problems are encountered in other homes.

Principal Findings:

Stormwater Management

1. Most homes had limited or no gutters and rainwater was routinely allowed to pond and stand alongside the homes.
2. The ponding resulted not only from the limited gutter systems but also from the lack of positive drainage away from the homes. In some homes there were depressions in the soil inside the drip lines where water had run off the roof.
3. Flashing and siding were not always installed, leaving paths for stormwater to penetrate the structures.
4. Consistent with not maintaining the imperviousness of the outer skin of the homes, the stucco on an older Styrofoam based home had deteriorated, allowing significant water penetration. If the foam in the walls of this home contacted the ground, this would be an additional mechanism for water to enter the home.
5. Some potential openings along expansion joints were not completely sealed.

Bathroom and Kitchen Ventilation

Several homes had inadequate ventilation or improperly exhausted ventilation, which can lead to elevated interior moisture levels including:

1. Ducts vented to gables and not to the outside.
2. Some fans were not ducted at all, but vented directly to the attic.

3. Most kitchens had recirculating fans, which do not remove any moisture.
4. Duct tape should never be used to seal ducts (use duct mastic or butyl-backed metal tape).
5. Vents should be smooth metal ductwork with a minimum of bends and the shortest length necessary.
6. Existing bathroom fans should be replaced with low-sone models and controlled by timers so that they continue to operate for at least 20 minutes after use of the bathroom.

Condensation

Condensation can concentrate sufficient moisture to promote mold growth. Although moisture removal with proper ventilation will eliminate most condensation, we noted the following conditions that can cause condensation:

1. Use of thick material for drapes.
2. Use of metal-frame windows. Metal frames are highly conductive and are often sufficiently cold enough to allow water to condense.
3. Possible condensation (or rainwater) on combustion air intake.
4. A potential thermal bridge in the Styrofoam house (where an incompletely sealed void allows cold air in that may conduct cold to the interior surface).

Maintenance and Quality Control

Part of moisture control requires attention to details that prevent moisture from entering the home. We noted the following items that either were never installed or had not been maintained:

1. Missing flashing and/or siding.
2. Missing attic access hatch cover.
3. Stucco deterioration.
4. Missing exhaust ducts.
5. Apparent plumbing leak.

It is important that residents notify ATOHA immediately regarding moisture and mold problems and that these concerns be promptly investigated. An easily fixed untreated leak can quickly turn into a complicated, expensive mold problem.

Exterior Conditions

We noted the following additional problems on the exterior of the home:

1. One home apparently had either a leaking wastewater pipe or a leaking hose bib pipe at the back of the home. This leak caused water to enter the bedroom on the other side of the wall, causing mold and moisture problems.
2. Dirt was allowed to accumulate on the vinyl siding. While vinyl is not a food source for mold, the dirt on the siding allowed mold to grow on the siding.

Health and Safety

Although not directly related to mold and moisture problems we noted one home where a garage was being converted into a bedroom. We advise ATOHA to carefully monitor this situation. For this home, we recommend the installation of low volume ventilation (no greater than about 20 CFM) and a carbon monoxide detector in proximity to the utility closet.

INTRODUCTION

The assessment team responded to a request from the Eastern/Woodlands Office of Native American Programs to assess site and structural conditions contributing to mold and moisture problems in homes managed by Apache Tribe of Oklahoma Housing Authority (ATOHA) located in Anadarko, Oklahoma, approximately 60 miles southwest of Oklahoma City, and to inspect new homes under construction. Paul Francisco and Eugene Goldfarb conducted the investigation on March 8 - 9, 2005. Inspected units were pre-selected by ATOHA.

The moisture problems reported in the homes include:

- Mold in bathrooms
- Window condensation
- Mold on siding
- Mold on floors (rugs), walls and baseboards

Interior mold was found in three inspected homes. The problems in two homes can be addressed with relatively modest measures. The third home, an “experimental” Styrofoam-stucco structure, poses a more difficult dilemma. The site visit team could not assess the two primary features that determine the course of a comprehensive repair strategy:

1. What provides the structural support?
2. How are the walls connected to the foundation?

If the structural support is provided by a sheathing external to the foam, it may be possible to attach new siding over the existing finish and to the sheathing. If the structure is via concrete internal to the foam the above strategy is not an option.

The foam should not contact the ground. In addition, the slab should be exposed at the base of the exterior walls. The stucco sheathing extended all the way to the ground at the time of assessment, so any contact between the foam and ground could not be determined. Removal of the lower portion of the stucco should identify the detailing. If the foam extends to the ground, this would be a likely source of the water causing the mold at the base of the walls inside the home. If the foam extends to the ground, and the foam is attached to an external sheathing, it may be possible to remove the lower portion of the foam to prevent the ground contact and to expose the slab.

Although almost any problem can be solved, the relevant question is usually whether the solution is cost effective. The current state of disrepair in the home dictates that ATOHA determine the structural details of the home and identify areas with water damage, replace damaged sections, and then perform extensive work to provide a long-term solution to the exterior of the home. Simply patching the cracks in the stucco will almost certainly lead to new occurrences of cracking, because the current cracks provide a

measure of stress relief that would be removed by patching. Therefore, consider a different exterior, even if that exterior is attached over the existing stucco. ATOHA should carefully assess these costs versus the benefit before undertaking such expensive repairs.

The overall conclusions of the visit include:

1. That there were no serious endemic problems in ATOHA homes.
2. Only minor modifications are suggested for the new construction.
3. ATOHA should consider improving its response to water related maintenance problems.
4. The home with mold under the carpets and along the baseboards was subject to problems both of the home (bulk water problems at the foundation) and of the occupants (no operable mechanical ventilation, high occupancy).
5. ATOHA should evaluate the structural details of the Styrofoam stucco home to determine whether relatively simple long-term repairs are possible.

Three principal issues highlighted by this study include:

1. Develop effective methods for handling rainwater. Water should not pond next to a building's foundation. ATOHA should consider the installation of gutters, and extensive grading to provide positive drainage.
2. Improve ventilation. We recommend that all exhaust fans (kitchen and bathroom) duct outside and replace existing bathroom fans with low-sone models controlled by timers so that they continue to operate for at least 20 minutes after the use of the bathroom.
3. Improve maintenance to identify and fix water and moisture problems in a timely manner. Residents should understand the significance of water and moisture issues and inform the ATOHA staff to ensure problems are identified and corrected. We recommend mandatory attendance at annual homeowner/tenant clinics as part of the annual recertification process. At these clinics ATOHA would provide instruction on home maintenance issues, such as identifying and repairing leaks, checking for disconnected dryer vents, etc. We also recommend that occupants be asked to complete a survey based on Housing Quality Standards (HQS), with additional questions on mold and moisture conditions in their homes, during the annual recertification process. Completing the survey further engages residents in their own home maintenance. Furthermore, the survey responses provide additional information to the housing authority on unreported problems, especially leaks and inoperable fans that might contribute to an unsafe, unhealthy home environment.

SECTION 1 – METHODOLOGY

Visual inspection and various airflow measurements were used to assess mold and moisture conditions in the homes.

The results of the mold and moisture assessments were compiled on a spreadsheet, with broad categories of common moisture problems noted. This data is presented in Appendix A of this report. Findings and recommendations for individually inspected homes are presented in Appendix B.

Visual Inspection

Housing inspections consisted of visual assessment of mold and moisture conditions. Assessment forms developed for the *Chicago Mold and Moisture Project* (a HUD Healthy Homes Program) were used to record information. The assessment forms are organized for a room-by-room inspection. All rooms were examined for water damage and evidence of mold. Assessment of kitchens, bathrooms, utility rooms, crawl spaces and attics included additional inspection relating to plumbing, localized ventilation, water entry and other moisture source issues.

The exterior of the homes were inspected for rainwater and snow melt management, including site grading, roof condition and gutter system.

Residents were interviewed to gather history on moisture problems, plumbing leaks, site drainage issues, winter condensation, health issues, number of occupants and other useful information that could be offered.

Digital photographs were taken at each home to visually record notable conditions.

SECTION 2 – OKLAHOMA APACHE HOUSE DESCRIPTIONS

ATOHA manages approximately 300 homes in Anadarko, Oklahoma of which about 100 are Low Rent and the rest are Mutual Help. Five existing single-family homes and one new townhouse were inspected. Inspected homes were all built within the last ten years but varied greatly in their method of construction. All had slab-on-grade foundations. Three were stick built, one used SIPs (Structural Insulated Panels) and one was an “experimental” Styrofoam-stucco home. The new townhouse also used SIPs.

The stick built homes were 2” x 4” construction. Sidewall insulation could not be inspected and is assumed to be R11-R13 fiberglass batts. Attics were insulated with approximately 10 inches of blown fiberglass (approximately R-21 to 27). The attics had no signs of mold or moisture problems. Insulated central supply and return air ducts are located in the attics. Soffit and ridge vents are the common attic ventilation strategy.

SECTION 3 – FINDINGS

3.1 Stormwater Management

Mold indicates a water or moisture problem. If sufficient rainwater is allowed to penetrate a home, either through foundation walls, cracks in the exterior, or missing or defective flashing or siding, mold will result (Figure 1). Rainwater management can be greatly improved at the homes that we visited. Many homes had very few gutters, so most rainwater ran off the roofs and ponded on the site. The water often set right against the foundation. Any break in the integrity of this barrier could allow a substantial volume of water to enter the structure. For example, in one home, water entered through an incompletely sealed expansion joint (Figure 2). This type of situation also prompted ATOHA to construct new porches at the front and rear entrances of one home (Figure 3).

Besides ponding, rainwater may also penetrate through failures in the home's exterior. We noted missing siding and flashing at one home, stucco with significant cracks at one home (Figures 4-5), and holes in the siding at one home (Figures 6-8).

3.2 Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Properly operating and vented exhaust fans and clothes dryers remove moisture from bathrooms and homes. Although most of the inspected homes had bathroom exhaust fans, the fans did not vent to the outside. In the "best" cases, the vent stopped at



Figure 1: Missing siding



Figure 2: Incompletely sealed expansion joint



Figure 3: No gutters; porch added to protect from rain



Figure 4: Cracks in stucco windowsill



Figure 6: Potential water entrance



Figure 5: Cracks in stucco

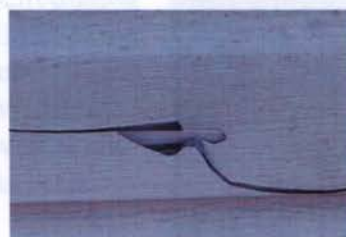


Figure 7: Hole in vinyl siding



Figure 8: Hole in vinyl siding

the gable (Figure 9) but we also found fans without any ductwork (Figure 10), such that the exhaust was blown into the attic insulation and then into the attic. In some cases, fans without ducting had blown a cavity around them in the insulation, whereas others remained completely covered. The home with Styrofoam and stucco did not have any exhaust fans. Typically an "on/off" switch controlled bathroom exhaust fans. All the bathroom fans were quite noisy. Occupants tend not to use noisy fans.

Bathroom exhaust fans should provide a minimum ventilation rate of 70 CFM. None of the bathroom exhaust fans vented at this rate. It is not unique to the Apache housing stock to have bathroom fans measuring below their rated exhaust capacity. This is commonly seen in all housing types, regardless of economic strata. One of the most common reasons for not achieving the rated performance for each fan is the use of flex ducts and/or excessive bends, each of which slows air movement. Use vents of smooth metal ductwork with a minimum of bends and the shortest length necessary.

One home had a kitchen fan that exhausted to the outside. Three homes had recirculating kitchen fans (Figure 11), and the remaining two homes did not have kitchen fans. Recirculating fans can remove some grease and solid cooking residue, but have no effect on moisture. Venting kitchen exhaust fans to the outside is imperative to controlling moisture levels while cooking, especially in a home that has been weatherized.



Figure 9: Exhaust fan ducted to gable vent



Figure 10: Unducted exhaust fan venting into attic insulation



Figure 11: Recirculating kitchen fan

3.3 Condensation

Condensation often provides enough moisture to allow mold growth. Although moisture removal with proper ventilation will eliminate most condensation, the use of metal windows can leave a cold surface in the interior. This cold surface will condense moisture if the ventilation is weak and the humidity is high enough (Figure 12). Heavy draperies can also lead to condensation on windows (Figure 13). Most homes place the supply air vents near the perimeter walls so that the hot air will wash moisture off the window surfaces. If heavy draperies are used, they will trap the moist air in a dead pocket and promote condensation. Furthermore, they may act as insulation between the window and the warmer house air.



Figure 12: Condensation on metal window frame



Figure 13: Heavy draperies can lead to condensation on windows

3.4 Bulk Water Problems

Several homes had bulk water problems or had reported bulk water problems in the past. While some of this can be attributed to stormwater management, discussed in Section 3.1, some was due to other deficiencies.

The home with Styrofoam and stucco had significant mold at the base of the walls and in a location in the center of one wall (Figures 14 and 15). This was almost certainly due to water penetrating the wall from outside. If the foam contacted the ground, this could lead to soil moisture being brought up and into the wall.



Figure 14: Mold in center of wall



Figure 15: Mold at base of wall

At one home, a pipe leaked below ground at the perimeter of the home. The brick was wet, as was a section of ground below this wet brick (Figure 16). All other ground was dry. The leaky pipe may be a wastewater pipe or a pipe taking water to the hose bib on the rear of the home.

3.5 Exterior Mold

Mold was found on the exterior of the vinyl siding at several homes (Figure 17). This mold was unsightly, and could stain the siding. Vinyl siding is not a food source for mold, and its integrity is unaffected by mold. However, the siding had gotten dirty and had not been cleaned. The dirt acted as the food source.

3.6 Conditioning Systems

Most of the homes had gas furnaces for heating with integrated air conditioners. Two homes had heat pumps. Homes with gas furnaces also had gas water heaters, while homes with heat pumps had electric water heaters. Two sites had problems with their systems.



Figure 16: Wet area at perimeter of home



Figure 17: Mold on vinyl siding



Figure 18: Dirty air conditioner outdoor coil



Figure 19: Disconnected flue pipe

At one site, the outdoor unit of the air conditioner was located under an eave that did not have a gutter. A portion of the coil that was most directly under this eave was extremely dirty (Figure 18). This reduces the efficiency of the air conditioning unit.

At a different site, the flue from the water heater was disconnected from the top of the water heater (Figure 19) and was also loose where it entered the attic (Figure 20, next page). This allowed moisture and other flue gases to enter the closet, which was located in a garage that was being converted to a bedroom. In addition, at this site the vents to

allow for combustion air were exceptionally long, extending several feet above the roof (Figure 21). This length is unnecessary for this type of vent.

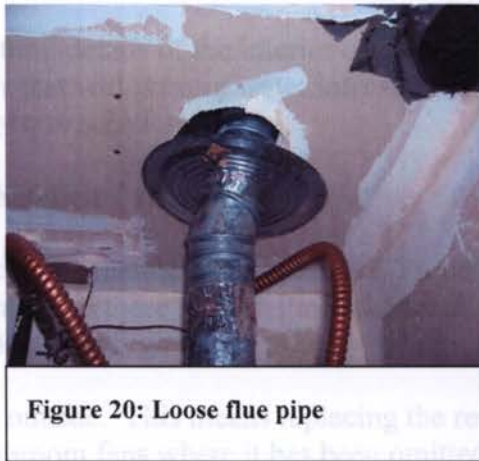


Figure 20: Loose flue pipe

3.7 Garage Conversion

Although not directly related to mold and moisture problems, we noted one home where a garage was in the process of being converted into a bedroom. The furnace and water heater were located in a utility closet in that room (former garage). Unless these types of appliances have sealed combustion chambers there is always a danger of backdrafting. Carbon monoxide sensors were in the home, but were installed near the older bedrooms, not in the converted one.

SECTION 4 – TECHNICAL RECOMMENDATIONS

The following recommendations are based on the site visit findings.

4.1 Stormwater Management

The general rule is that stormwater should not come in contact with the building foundation. The rainfall running down the roof and ponding against the foundation is unacceptable. Gutters or positive drainage are recommended. ATOHA should evaluate each site where water is entering a building and causing mold problems to determine the appropriate solution, using Section 5 for general guidance. Fill in any small depressions near the building and ensure the grade slopes away from the structure at all points. Use gutters, with complete downspouts and leaders, to move water away from the homes, eliminating drip lines beneath the eaves that channel stormwater into a narrow relatively flat space near the foundation (Figure 22). Install any missing flashing and siding, repair broken siding, and completely seal the expansion joint along the living room wall in one home. For the home with Styrofoam and stucco,



Figure 21: Long combustion air intake vents



Figure 22: Drip line between homes

determine the structural details of the interior of the wall, and take appropriate measures to install an exterior that will prevent water intrusion. Simply sealing the cracks in the stucco is not a long-term solution.

4.2 Bathroom & Kitchen Exhaust Fans

Bathrooms and kitchens generate much moisture. Properly operating exhaust fans remove this moisture from these spaces. Place the maintenance of bathroom fans and the replacement of broken fans high on the priority list.

Duct all fans to the outside. This means replacing the recirculating kitchen fans, adding ductwork to the bathroom fans where it has been omitted, and extending the duct through the roof. Initial efforts should be made in homes with current mold problems.

Replace inoperable or poorly operating bathroom exhaust fans. Replace noisy fans with quiet fans, especially when bathroom rehabilitation is planned, or when mold is found in bathrooms. Bathroom fans should be rated for a minimum 70 CFM at 0.25" of static pressure (the rating provided on the box is generally at 0.10" of static pressure).

New bathroom fans should have sone ratings no higher than 1. Sone is a rating for sound – the lower the sone rating, the quieter the fan. Occupants tend not to use loud fans because of the noise. Low-sone fans include Broan *Solitaire* and Panasonic *WhisperCeiling* and *WhisperLite* series. Low-sone fans generally cost between \$75 and \$100.

Replace flexible ribbed exhaust vents with smooth metal exhaust vents (Figure 23). Minimize duct length, turns and bends in the ductwork; a two to three foot run should be before the first elbow and all elbows should have a long radius (Figure 24). Smooth duct provides less resistance and improved flow over ribbed ductwork. Recommend to occupants to clean dust and lint regularly from bathroom fan grilles.



Figure 23: Smooth metal exhaust duct

Do not use duct tape for duct installation because it is prone to drying out and failing. For metal ducts, use sheet metal screws for mechanical fastening, with duct mastic used to seal any remaining small leaks. When making repairs to duct systems remove any duct tape, make the attachment as described.

Elbows

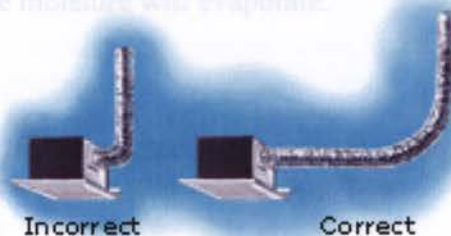


Figure 24: Proper exhaust duct design

Attach flexible with a cable tie. Use high-quality butyl-backed metal tape.

Replace fan on/off switches with 60-minute timer switches (Figure 25) and advise occupants to operate fans for at least 20 minutes following showering or bathing. Timer switches cost between \$15 and \$50.

Replace any existing combination bathroom light/fan switches with fan delay timers. A fan delay timer is a two-function switch that is typically wired to a fan and a light (Figure 25). When the switch is turned-on, both the light and exhaust fan are turned-on. When the switch is turned-off, the light is turned-off but the fan continues to operate for an extended period of time. The extended period of time can be adjusted from 1 to 60 minutes. Fan delay timers are about \$35.

Periodically inspect all bathroom and kitchen exhaust fan ducts. Ensure that exhaust ducts are vented outside, properly attached and sealed to the exhaust fan housing and to roof or wall vent caps.

Periodically inspect dryer vents and make the following corrections as necessary:

1. Install dryer vent when missing or damaged.
2. Replace crimped or cracked dryer vents.
3. Reconnect disconnected dryer vents.
4. Replace plastic ribbed dryer vents with smooth metal vents as space permits.

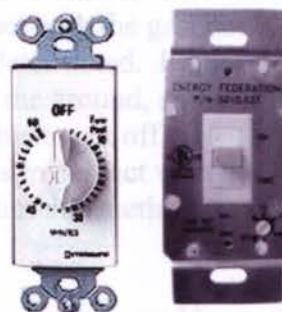


Figure 25: 60-minute timer (left) and fan delay timer (right)

4.3 Condensation

As noted in Section 3.3, condensation frequently occurs on windows in problem homes. It is possible that improving ventilation by removing sufficient moisture will remedy this situation. If this does not occur, or if ATOHA desires to provide an added measure of protection, ATOHA should consider replacing the existing metal-frame windows with windows that provide a better thermal break (e.g. wooden, vinyl) and thus stay warmer.

Address the problem of condensation on windows with heavy draperies by counseling occupants to periodically open the drapes so that the moisture will evaporate.

4.4 Bulk Water Problems

The problems with water intrusion into the walls at the home made with Styrofoam and stucco cannot be solved by simply patching the cracks in the stucco. Solving these problems requires a more comprehensive approach.

The first step is to determine the exact construction of the walls. Of primary importance is what is providing the structural support. Possibilities include some sort of sheathing external to the foam or concrete internal to the foam. If there is external sheathing that can accommodate the attachment of additional exterior siding, this can be done over the existing stucco. If the structure is from internal concrete then this repair method is not an option.

The second step is to determine the structural details at the ground. General, some slab at the ground should be exposed and the foam should not be in contact with the ground.

The stucco extended to the ground, so this detailing could not be determined. Remove the lower stucco to expose the slab. If the foam is in contact with the ground, and if it is simply attached to sheathing external to the foam, it may be possible to cut off the bottom portion of the foam to eliminate this contact. If the foam is in contact with the ground and the structure is provided by concrete internal to the foam this method is not an option.

At the home with a section of wet brick on the rear exterior wall and wet ground beneath this brick, minor excavation work should identify the cause of this water. The water is almost certainly leaking from either a wastewater pipe or a pipe that takes water to the hose bib on the back of the home. It may be necessary to run some water in the home to positively identify the leak. Repair this leak prior to installing any new floor coverings in the bedroom adjacent to this wall.

4.5 Exterior Mold

Wash off the mold on the vinyl siding with a low-pressure spray, such as from a garden hose. Some scrubbing may be required. This will be a recurring problem, and will require periodic washing to prevent the reoccurrence of mold growth.

4.6 Conditioning Systems

The conditioning systems were mostly in good shape. Clean the dirty outdoor air conditioner under the eave. Install gutters, or at least a rain diverter, to prevent rainwater from falling on the air conditioner.

Reconnect the disconnected flue pipe to the water heater. Inspect the flue pipe through the closet ceiling and repair to assure durability.

Address the combustion air vents at this home also. On the inside of the closet, remove the failing duct tape and replace with more durable products such as drywall, sheet metal, or wood. Above the roof, shorten the excessively long pipes, extending the vents to just out of the roof and covered with vent caps.

4.7 Garage Conversion

For health and safety reasons, the home converting the garage into a bedroom should receive special attention to the repairs to the water heater flue and combustion air intake vents. Since the furnace and water heater are located in a utility closet in the bedroom formerly the garage, install carbon monoxide sensors near the utility closet. In addition, we recommend installing low volume exhaust ventilation to prevent the build up of gases to a dangerous level. This ventilation should be less than 20 CFM, to prevent backdrafting. It should also not be supply ventilation because a backdrafting event in the supply ventilation would only serve to push the pollution into the rest of the home.

4.8 Occupant Education

Occupant cooperation is essential to minimize moisture and other indoor air quality (IAQ) problems. Instruct occupants on the following:

1. The importance of using bathroom and kitchen exhaust fans during and after bathing and cooking activities to remove moisture from these spaces. As inoperable fans are replaced, provide similar instructions.
2. Change furnace filters on a monthly basis during the winter and every three months the rest of the year.
3. Promptly report plumbing leaks. Recognize the difference between plumbing leaks and “sweaty” pipes and fixtures. Wipe up moisture from “sweating” pipes and fixtures.
4. Show occupants combustion air intakes for their furnaces. Explain the importance of keeping these intakes open. Blocking these intakes may cause a furnace backdrafting problem (combustion gases spilling into the home rather than venting to the outside). Backdrafting appliances can cause serious health problems.
5. Consider mandatory attendance at annual homeowner/tenant clinics as part of the annual recertification process. At these clinics, provide instruction on home maintenance issues, such as identifying and repairing leaks, checking for disconnected dryer vents, etc.
6. During the annual recertification process, ask occupants to complete a survey based on Housing Quality Standards (HQS) with additional questions on mold and moisture conditions in their homes. Completing the survey further engages residents in their own home maintenance. Furthermore, the survey responses provide additional information to the housing authority on unreported problems, especially leaks and inoperable fans that might contribute to an unsafe, unhealthy home environment.

SECTION 5 – DISCUSSION OF COMMON PROBLEMS

5.1 Site Drainage

Good site drainage includes managing water that lands on the roof as well as water that lands on the ground. The roof should be designed and built so that the water that lands on the roof is moved out to the edge of the roof. When rain falls on a soil surface, some of it will percolate downward through the soil—more in sandy soils and less in clayey soils. The water that does not percolate downward will move along the soil surface following the slope, out to the downhill edge of the site. The best way to prevent mold and moisture problems in houses is to make sure that rainwater moves off the roof and across the site and off the property. Houses often have problems if water is allowed to accumulate in the soil that is in contact with the foundation. The soil that is in contact with the foundation should, in a well-managed property, be the driest soil on the site following a rainstorm. Houses with dry foundations (basements, crawl spaces and slabs) are usually dry houses. To keep the foundation dry, keep the soil dry that is next to the foundation.

Keeping the soil that touches the foundation dry involves a few general rules, together with some specific guidelines.

1. The first general rule is the rule of concentration - damage is worse where greater quantities of water are concentrated. A valley on a roof acts like a funnel, with the greatest concentration of water at the base of the valley. Gutters act like funnels that collect water from the edge of the roof and concentrate it in the downspout. On the land, valleys and swales act like collectors or funnels that concentrate the water on the site. If the water management design makes use of funnels (such as valleys, gutters or swales) then they require maintenance to make sure they work as they are intended. Damage is worst where a valley, gutter or swale is blocked.
2. The second general rule is the “ground-roof” rule - treat the soil surface as if it were a low-slope roof surface. Pitch the surface away from the house - the steeper the pitch, the better the drainage. Determine the best methods to move all the water to the low edge of the site. Avoid areas near the building that can act as water collectors.

Specific site drainage guidelines include:

1. The home should be built on a hill, not in a hole with a minimum of eight inches of exposed foundation between the ground and the beginning of the exterior finish. If there is sufficient exposed foundation, site grading at the home can be improved. If the home hugs the ground, improvements at the foundation are more difficult.
2. Identify localized dips and holes immediately adjacent to the foundation and fill with soil. Tamp the fill material to prevent future settling. Provide sufficient fill material so that water drains away from the foundation.

3. If the home has no gutters or the gutters are ineffective, then the base of the soil around the home has to serve as a gutter itself. It should have a surface that helps prevent splash back onto the exterior finish of the home. It should be designed with pitch so that it effectively moves water away from the home.
4. Good tamping or compaction of the backfill is very helpful because it helps keep water up on the surface where it can be managed by slope. Soil at the outside corners of the foundation, where the downspouts are usually found, can always be tamped because the corner will never collapse inward.
5. Bushes and other plantings may be very helpful, especially if their root balls soak up a lot of water. Also they can be planted strategically near downspouts so that downspout extenders are less likely to be kicked off or removed during lawn mowing.

The following information is provided should ATOHA consider the installation of gutter systems.

Gutter systems collect and distribute rainwater and snowmelt from the roof. Flashings around chimneys and vents should be watertight.

1. Include waterproofing underlayment at the eaves as part of re-roofing to help prevent water damage caused by ice dams.
2. Gutters can be an effective rainwater/snow management system. Pitch the gutters to the downspout. Short gutters may be hung level. In hip roof houses, consider using downspouts only on the downhill side, not on the uphill side. In areas with a moderate amount of trees, consider large gutters and downspouts where leaves and debris can be flushed more easily. Make sure the gutter hangers are solid so that they keep the gutter from sagging.
3. Downspouts should be secured to the house. They should never be undersized, but some oversizing is acceptable. Fasten elbows and straight sections together with pop rivets—screws that project into the downspout can lead to clogging.
4. At the base of the downspout, direct the water away from the foundation of the building, past the backfill onto the undisturbed soil, which may be 3 feet to 5 feet from the edge of the home. If it is allowed to dump water close to the foundation, into the backfill, it will concentrate the water next to the foundation—precisely the wrong place for the water to be. The traditional way to discharge the water away from the house involves using downspout extenders (sections of straight downspout) or splash blocks. Both of these are often disturbed when lawns get mowed. A notched section of downspout that is hinged to the elbow at the base of the downspout can solve this problem. The soil at the base of the downspout should slope away from the house at a minimum of 5% slope. Six inches of fall in the first 10 feet away from the house gives a 5% slope.

5. Keeping gutters clean in wooded areas can be a maintenance issue. A gutter guard system can help keep debris out of the gutter, thus minimizing maintenance, while allowing water to drain into the gutter.

Two such gutter guard systems are the *PermFlow Gutter Guard System* and the *WaterFall Gutter Guard System* (Figure 26). These systems cost about \$4.50 per 3' section and are designed for a 5" K style gutter (8' sections are sold to contractors).



Figure 26: PermaFlow Guard System and the WaterFall Gutter Guard System

5.2 Bathroom & Kitchen Exhaust Fans; Laundry Room

Bathrooms, kitchens, and laundry rooms are natural moisture sources simply by the nature of their function. Showers result in 100% humidity in bathrooms. Kitchens are used for cooking and cleaning. In laundry rooms, clothes dryers must remove large quantities of water from wet clothes. By removing moisture at the source in these areas, exhaust ventilation serves as a moisture source control strategy. Exhaust ventilation dilutes the moisture and places the room in a negative pressure, thus limiting the spread of moisture to the rest of the house until most of the moisture has been removed to the outside.

Vent bathroom exhaust fans, kitchen exhaust fans and clothes dryers to the outside rather than into the living space. Venting to the crawl space and attic can lead to moisture problems occurring in these areas. For this reason, localized exhaust ventilation requires ductwork.

The effectiveness of exhaust fans is based on the power of the exhaust fan, length and type of exhaust duct, and cleanliness of the fan grille. When there is excessive resistance in the ductwork, the exhaust fan motor may not be powerful enough to vent sufficient airflow through the duct. The longer the duct length, the greater the static pressure in the duct and the less air flow through the duct. Turns and bends in the ductwork also increase the static pressure and reduce flow. Similarly, a smooth duct provides less resistance and improved flow over ribbed ductwork. For all types of exhaust ventilation,

using round, smooth sheet metal ductwork is recommended. A dirty intake grille will also greatly increase resistance and reduce airflow.

Fan capacity is typically listed at 0.10" and 0.25" of static pressure. Bathroom exhaust fans should provide a minimum ventilation rate of 70 CFM at 0.25" of static pressure. Selecting a fan capacity at 0.10" static pressure is appropriate only if the exhaust duct is smooth, straight (no more than one elbow) and less than 15 feet in length. For example, a bathroom fan with an exhaust ventilation rate of 90 CFM or 100 CFM (at 0.10") may be required to obtain 70 CFM at 0.25" of static pressure if there are numerous elbows, the exhaust duct is ribbed and the length is over 15 feet. Fan performance curves should be reviewed to determine ventilation rates at 0.25".

Replace non-operable, kitchen exhaust fans and kitchen recirculating fans, with fans venting to the outside and having a minimum exhaust capacity of 150 CFM. Under no circumstances should recirculating fans be installed in place of the kitchen exhaust fans.

Dryer vents should be smooth-surfaced rigid duct. Non-combustible flexible metal duct approved for dryer venting may also be used. Duct joints should be in the direction of air flow. Ducts should not be fastened with screws or fasteners that extend into the duct. Length of the duct run should be minimized, especially with flexible metal duct. Flexible metal duct should be installed without dips or sags. Dryer vents extending through attics should be insulated.

Minimum duct diameter should be 4 inches and length should not exceed 25 feet from the dryer outlet to the termination point. If duct length is greater than 25 feet, 5-inch diameter duct should be used.

Dryer vent caps should have a backdraft damper that closes when the dryer is not being used. Insect screens or small wire cages should not be installed over the vent cap.

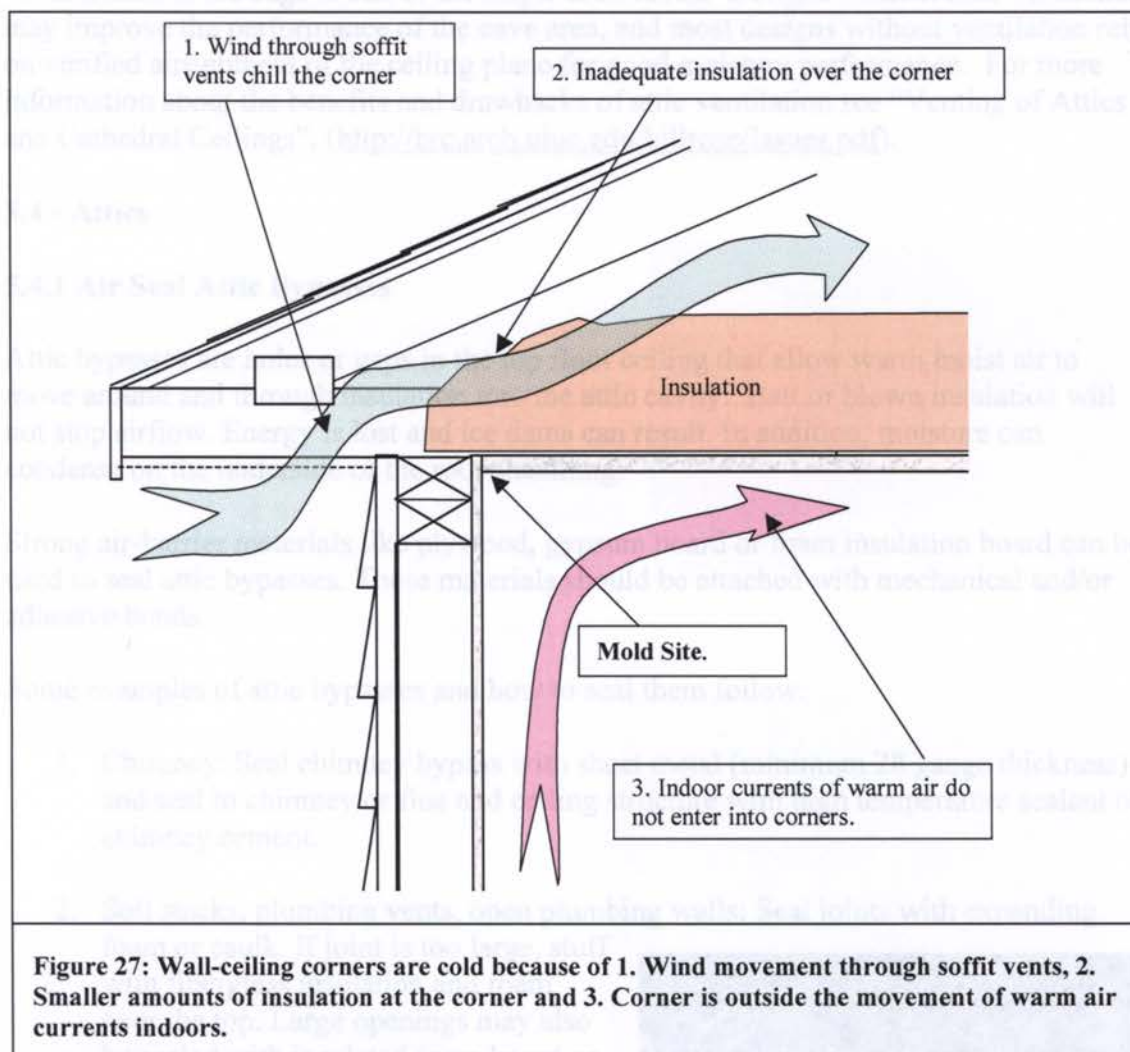
5.3 - Exterior Wall/Ceiling Juncture

High relative humidity and cold surfaces can lead to mold growth. If a surface approaches the dew point temperature based on the relative humidity, water will condense, be quickly absorbed by the material, and raise the moisture content of the surface. At some point, the moisture content can be sufficient to promote mold growth. This process often occurs at the wall/ceiling junction on exterior walls.

There are at least three reasons why the exterior wall/ceiling juncture gets cold:

1. Cold wind may enter through soffit vents and pass through the porous insulation material, degrading its thermal performance,
2. The insulation may have been poorly installed resulting in reduced amounts of insulation over the plate, and

3. The geometry of the corner usually means that slow-moving currents of warm air may not be able to reach into the corners (Figure 27).



The dark spots occur where the interior surfaces are the coldest. They occur there because that is the hardest place to insulate effectively. It is difficult to carefully insulate the exterior edge of the attic, especially in homes with low-pitch roofs. With batt insulation, special pusher sticks may be used to get the insulation out to the edge. With loose fill insulation, the outside edge should be prepared correctly so that it is packed with insulation.

Utilizing two-part spray foam over the top plate should provide the necessary R-value and air sealing to warm the interior surface temperature of the wall/ceiling juncture. This measure combined with better indoor relative humidity control (bathroom exhaust fans, venting clothes dryers, resolving site drainage issues) should eliminate any mold problem at this juncture.

Many individuals and organizations (including model codes) stress the importance of attic ventilation. While it has some benefits, it also has some drawbacks. Wind washing of insulation at the edge is one of the major drawbacks. Designs without attic ventilation may improve the performance of the eave area, and most designs without ventilation rely on verified airtightness of the ceiling plane for good moisture performance. For more information about the benefits and drawbacks of attic ventilation see “Venting of Attics and Cathedral Ceilings”. (<http://brc.arch.uiuc.edu/billrose/Issues.pdf>).

5.4 - Attics

5.4.1 Air Seal Attic Bypasses

Attic bypasses are holes or gaps in the top floor ceiling that allow warm moist air to move around and through insulation into the attic cavity. Batt or blown insulation will not stop airflow. Energy is lost and ice dams can result. In addition, moisture can condense on the underside of the roof sheathing.

Strong air-barrier materials like plywood, gypsum board or foam insulation board can be used to seal attic bypasses. These materials should be attached with mechanical and/or adhesive bonds.

Some examples of attic bypasses and how to seal them follow:

1. Chimney: Seal chimney bypass with sheet metal (minimum 28 gauge thickness) and seal to chimney or flue and ceiling structure with high temperature sealant or chimney cement.
2. Soil stacks, plumbing vents, open plumbing walls: Seal joints with expanding foam or caulk. If joint is too large, stuff with fiberglass insulation and foam over the top. Large openings may also be sealed with insulated foam board or scrap gypsum board (Figure 28).
3. Housing of exhaust fans and recessed lights: Caulk joints where housing comes in contact with ceiling. Using gypsum board, construct a box around recessed light fixtures to prevent overheating and/or fire. Provide a minimum 3-inch clearance between the box and the sides of the fixture.



Figure 28 - Air sealing a plumbing wall

Construct it to extend four inches above the installed insulation. Cover the box with gypsum board and seal to the sides of the box, but do not cover with insulation. If there is insufficient clearance to install a box 4 inches higher than

the insulation, do not cover the box and use an appropriate barrier to keep the insulation 3 inches away from the fixture.

4. Wiring and conduit penetrations: Seal joint with caulk or low expanding foam.

5.4.2 Insulate and Air Seal Attic Hatches

A non-air sealed attic hatch is another type of bypass. Mold can condense on access hatch blocking if not air sealed (Figure 29).

The hatches should be air sealed with weatherstripping or gasket (Figure 30). Install latches to lock the hatches in place and provide positive closure.

Insulate attic hatches to a minimum of R38 but no less than R19. A lightweight attic hatch may be cut from damaged insulated foam core doors (Figure 31). The door has an R-value about 7. Batt insulation may be attached to the back of the door panel to achieve the desired R-value. The door panel is pre-finished, light-weight and requires no additional painting.

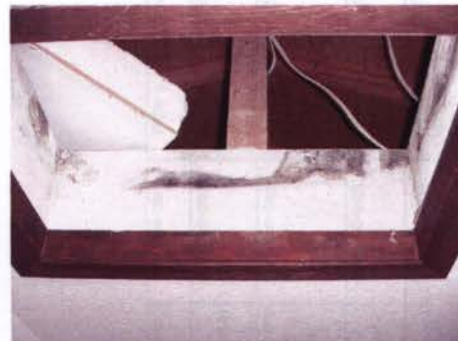


Figure 29 – Mold growth on a non-air sealed attic access opening

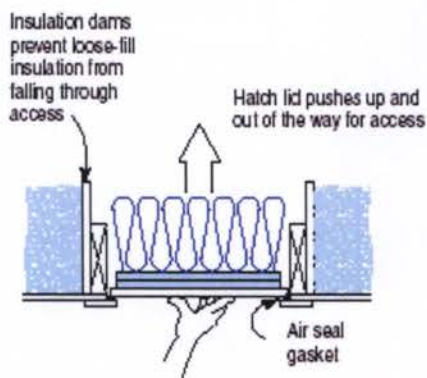


Figure 30 – Air sealed and insulated attic access hatch



Figure 31 – An access hatch cut from an insulated foam core door provides a quick R7 hatch

1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19
Inspection Number	Address	HUD Program	Building Age Years	Occupancy	Foundation Type	Model and Framing Type	Heat Type	Site Drainage Problems	Gutter System Problems	Leaks from Exterior	Wet Basement or Crawl Space	Plumbing Problems	Bathroom Problems	Exhaust Ventilation	Exterior wall/ceiling problems	Attic Problems	Visible Mold (Column #)
1-1	209 Blackhawk Terrace	Low Rent	7	1 Adult,	Slab-on-grade	2 story; 2x4 wood frame	Natural Gas/FA	Yes	Yes	No	NA	No	No	Kitchen - recir Bath - yes	No	No	
1-2	511 E Kentucky	Mutual Help	8-Jan	2 Adults, 4 children	Slab-on-grade	Ranch; 2x4 wood frame	Natural Gas/FA	Yes	Yes	Yes	NA	Yes	Yes	Kitchen - yes Bath - yes	No	No	12,15
1-3	302 E. Colorado	Mutual Help	2	2 Adults, 2 children	Slab-on-grade	2 story; 2x4 wood frame	Natural Gas/FA	No	Yes	No	NA	No	No	Kitchen - recir Bath - yes	No	No	
1-4	604 E. Virginia	Mutual Help	2	1 Adult, 1 child	Slab-on-grade	Ranch; SIPs (Structural Insulated Panels)	Electric Heat Pump	Yes	No Gutters	No	NA	No	No	Kitchen - no Bath - yes	No	No	
1-5	602 E. Virginia	Low Rent	8 to 10	2 Adults, 1 child	Slab-on-grade	Ranch; Styro-foam with stucco finish	Electric Heat Pump	Yes	No Gutters	Yes	NA	No	Yes	Kitchen - recir Bath - No	Yes	NA	12,15,17
1-6	216 W. Mississippi, A	Low Rent	6 mo.	1 Adult	Slab-on-grade	Townhouse; SIPs	Natural Gas/FA	Yes	No Gutters	No	NA	No	No	Kitchen - no Bath - yes	No	No	

Inspection Number: 1-1
Address: 209 Blackhawk Terrace
Model Type: Ranch
Foundation: Slab on grade
Construction: 2" x 4" Wood Frame
Heat Type: Gas Furnace with A/C
Bedrooms: 3
Occupancy: 1
Age: ~7 yrs



Figure 1: 209 Blackhawk Terrace



Figure 2: Mold on vinyl siding



Figure 3: Missing leader and splash block



Figure 4: Recirculating range hood

Mold and Moisture

Conditions: No mold was within the unit, but was on the exterior of the vinyl siding on the northern exposure (Figure 2), probably caused by dirt on the siding.



Figure 5: Bathroom fan vented to gable vent



Figure 6: Insulation void under stiffener board

Site Drainage and

Rainwater Management:

Site drainage was flat. The extensive gutter system was missing some leaders and splash blocks, which, in one case, caused the water that ran down the downspout to carve a hole in the ground by the foundation and below the downspout (Figure 3). Despite the gutters, there was a drip line on the north side of the home where rain dripped off of the roof, indicating the gutters needed cleaning.

Bathroom/Kitchen: The kitchen had a recirculating fan (Figure 4). The downstairs bathroom fan exhausted to the gable end vent rather than venting to the outside (Figure 5) and had low efficiency and was not exhausting as much air as it was made to. The upstairs bathroom fan duct was not inspected. The upstairs fan had good efficiency.

Attic: The attic was insulated with approximately 10 inches of blown fiberglass insulation, except at a void under a stiffener board where the blown insulation had not penetrated (Figure 6).

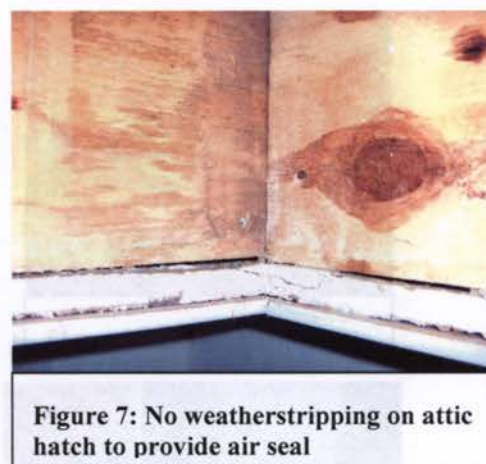
This void provided an opportunity for convection loops to increase heat loss through the ceiling, resulting in a cold spot on the ceiling. Under extended cold conditions, this could lead to mold growth. The attic hatch was not sealed with weatherstripping (Figure 7). This could allow some interior air to bypass the attic hatch and enter the attic.

Heating System: The home had a natural gas forced-air furnace with an air conditioner and all the ductwork located in the attic. Duct tape was used extensively in the installation to attach the wrapped insulation. Duct tape has been shown to often fail when used on ductwork, and a better type of tape is preferred, such as butyl-backed metal tape.

Occupant Notes: One adult lived in the three-bedroom home, with occasional visits from two children.

Recommendations:

1. Install leaders and splash blocks where needed on downspouts.
2. Carefully wash north siding to remove soil and dirt along with mold and mildew. A high-pressure wash will be faster and easier, but may get water under the siding and wet the sheathing. A low-pressure wash (e.g. with a garden hose) will take longer but poses less risk of wetting materials under the siding.
3. Push insulation into cavities where building materials blocked the blown-in insulation from filling.
4. Air seal hatches to attic using weatherstripping.
5. Vent bathroom fans all the way to the outside, not just to the gable vents.
6. Install mechanical or fan-delay timers as bathroom exhaust fan controls.
7. Install a kitchen range hood that exhausts to outside.



Inspection Number: 1-2
Address: 511 E Kentucky
Model Type: Ranch
Foundation: Slab on grade
Construction: 2" x 4" Wood Frame with brick facade
Heat Type: Gas furnace with A/C
Bedrooms: 3
Occupancy: 6
Age: ~8 yrs



Figure 1: 511 E. Kentucky

Mold and Moisture Conditions:

Mold had been reported for some time under the living room and rear bedroom carpets (Figure 2), on the bathroom walls, and around windows (Figure 3). Mold was also observed on the wall behind the toilet. The mouldings at the base of the rear bedroom walls showed signs of extended wetting.



Figure 2: Mold on bedroom floor (carpet had been removed)

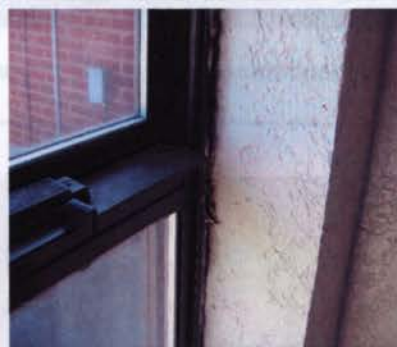


Figure 3: Mold around bedroom window

Rainwater Management:

The site was flat and the home had a very limited gutter system. A drip line was beneath the eaves of the home (Figure 4). Both ATOHA and the occupant reported water standing alongside the home after a rainfall event. It is likely that the water in the living room had entered through an unsealed expansion joint in the brick façade at grade from ponding after rainfall events (Figure 5).



Figure 4: Drip line below eaves



Figure 5: Expansion joint incompletely sealed at bottom



Figure 6: Bath fan exhausting to attic and no ductwork present

Bathroom/Kitchen: The kitchen fan exhausted to the outside but the bathroom exhausts were not connected to any ductwork (Figure 6). Mold was reported on the walls and behind the toilet. The room was recently painted, so this mold was only slightly visible. A small hole was at

the base of the wall behind the toilet.

Attic: The attic was insulated with sufficient blown fiberglass insulation. The attic access hatch was in the garage, so no air sealing of the hatch was necessary.

Heating System: The home had a natural gas forced-air furnace with an air conditioner, with all the ductwork located in the attic. The exterior condenser coil was located under the eave and the coil on the side facing the home was clogged with dirt and debris (Figure 7).



Figure 7: Clogged air conditioner coil

Water Penetration at Rear of Home: The rear bedroom showed evidence of significant long-term wetting. This was almost certainly caused by a plumbing leak at the back of the home. A wet spot was evident along the rear perimeter wall about four feet from the corner of the home (Figure 8). The ground immediately below this wet spot was saturated, while the ground on either side was dry. The occupant reported that this spot has been wet for eight years.



Figure 8: Water on brick at rear of house

It was likely that there was a leak in piping in the ground at this location. This piping could be either wastewater (there was a waste pipe access in the backyard) or where the plumbing makes a turn to go to the hose bib located on the rear of the home.

Occupant Notes: Two adults and four children lived in the home. There were no smokers in the household. One child had asthma and another had allergies.

Recommendations:

1. Locate and repair the probable leak in piping at the back of the home. It may be necessary to run the water in the home to locate the leak. Make this repair before any new carpet is installed in the rear bedroom.
2. Install low-sone bathroom exhaust fans in bathroom with fan delay timers and duct these fans through the roof.
3. Install a gutter system and ensure that stormwater is channeled away from perimeter of home. Although it is not improper to delay stormwater from entering storm drains (e.g. to use for rain gardens) it is important that these areas be some distance from perimeter walls. Do not allow water to stand against the perimeter walls of the home.

4. Carefully and fully seal the expansion joint in the brick outside of the living room, especially at the base.
5. Protect the A/C unit coils from stormwater, preferably with a gutter system but at least with a splashguard. Clean the coils.
6. Replace the windows. Highly conductive metal windows result in the metal often being cold which allows for condensation and promotes mold growth. If the other measures outlined (e.g. increased ventilation) do not eliminate the condensation problem then replace with non-metal windows.

Inspection Number: 1-3
Address: 302 E Colorado
Model Type: 1½ story
Foundation: Slab on grade
Construction: 2" x 4" Wood Frame
Heat Type: Gas furnace with A/C
Bedrooms: 3 (plus converted garage)
Occupancy: 4
Age: ~2 yrs



Figure 1: 302 E. Colorado

Mold and Moisture

Conditions: No mold was found inside. However, significant mold was found on the dirty exterior vinyl siding (Figure 2).



Figure 2: Mold on vinyl siding



Figure 3: Damaged gutter

Rainwater Management:

Gutters were on the front and back but not on the sides of the home. A portion of the rear gutter was bent and broken, most likely caused by a person hanging on it (Figure 3).

Bathroom/Kitchen: The kitchen had a recirculating fan. The bath fan exhausts could not be inspected, but likely vented only to the attic.



Figure 4: Failing duct tape around combustion air intake

Attic: The attic was insulated with approximately 10 inches of blown fiberglass insulation.

Heating System: The natural gas forced-air furnace with an air conditioner had all the ductwork in the attic. The furnace and water heater were located in a garage closet.



Figure 5: Excessively long intake ducts

Two ducts entered the closet from outside to provide combustion air. One terminated near the closet ceiling while the other terminated near the closet floor. Failing duct tape sealed the combustion air ducts where they entered the closet (Figure 4).

An excessively long portion of the combustion air intake ducts, which should just extend through the roof, was several feet above the roof (Figure 5). These long ducts did not improve the ability to draw in air, and the length increased the wind related problems.

Garage: The home had a natural draft gas water heater with two flue problems; (1) the flue did not attach to the draft hood above the water heater (Figure 6), permitting combustion gases to enter the closet and not exhaust out of the home, and (2) the flue was loose where it exited through the closet ceiling (Figure 7). Check whether a disconnect valve was within the attic.

The garage was being converted into a fourth bedroom. Since the furnace and water heater are in the enclosed garage closet, there was some concern about adequate ventilation for the gas appliances.

Occupant Notes: Two adults and two children lived in the home. One adult had asthma. No one smoked in the home.

Recommendations:

1. Replace damaged gutters. Consider gutters for all sides of the roof.
2. Carefully wash the north siding to remove soil, dirt, mold and mildew. A high-pressure wash will be faster and easier, but may get water under the siding and wet the sheathing. A low-pressure wash (e.g. with a garden hose) will take longer but poses less risk of wetting materials under the siding.
3. Extend the bathroom vent to the outside, not just to the gable vents.
4. Install fan-delay timers as bathroom exhaust fan controls.
5. Install a kitchen range hood that exhausts to the outside
6. Reconnect and align the water heater flue. Reestablish a proper connection of water heater flue to the closet ceiling and on outside. Shorten the combustion air intakes. Provide improved air sealing around the combustion air intakes by removing the duct tape and using rigid materials (e.g. wood, drywall) and caulk.
7. Install low CFM (maximum of 20 CFM) exhaust ventilation in the converted garage. This is important for health and safety because of the proximity of the utility closet and the confined nature of the garage. Do not install a larger fan, because this could encourage backdrafting of combustion appliances. Do not use a supply fan, because this could push pollutants into the rest of the home.
8. Install a carbon monoxide detector in the converted garage.



Figure 6: Disconnected water heater flue



Figure 7: Loose water heater flue at closet ceiling

Inspection Number: 1-4

Address: 604 E. Virginia

Model Type: Ranch

Foundation: Slab on grade

Construction: SIPs (Structural Insulated Panels), 8" walls, 12" cathedral ceiling

Heat Type: Electric Heat Pump

Bedrooms: 3

Occupancy: 2

Age: ~2 yrs



Figure 1: 604 E. Virginia

Mold and Moisture

Conditions: According to the ATOHA mold was at the front entrance, on the baseboards, and around the windows following heavy and prolonged rainfall in 2004. No other mold was reported or found.



Figure 2: Depression in soil adjacent to home



Figure 3: Soil rising to bottom plate

Rainwater Management:

The site was flat with no gutters. Depressions were found near the foundation (Figure 2) and where the earth near the foundation was close to the bottom plate above the slab (Figure 3). ATOHA recently constructed porches, front and rear, to keep the surface stormwater away from the entrances and prevent a recurrence of the 2004 problems. However, the potential for groundwater entry remains. The slab was poured several years prior to the home being built on it and any small cracks in the slab could promote groundwater intrusion. ATOHA should monitor this.



Figure 4: Unsealed penetration for ducts through ceiling

Bathroom/Kitchen: The kitchen did not have any fan, while the bathroom exhaust was noisy and did not vent to the outside.

Attic: There was no attic insulation, since structural insulated panels (12" thick) were used to construct a cathedral ceiling. In affect, this made the attic space part of the interior of the home. The attic hatch cover was missing. The accessible portion of the attic was restricted to a section along the center of the home through which the ducts for the heat pump ran.

Heating System: The home used a two-ton heat pump with the ducts in the attic. The ceiling penetrations through which the ductwork entered the attic were not sealed (Figure 4) although this is not as serious an issue with SIPs construction.

Building Exterior: The siding installation was not complete. The starter strip covering the bottom plate was missing alongside the home (Figures 5 & 6), allowing for potential rot and water penetration. The steel reinforcing the concrete slab was not trimmed at all locations, which could pose a safety hazard (Figure 7).

Occupant Notes: One adult and one child had lived in the home since October 2004. The child had asthma and allergies.

Recommendations:

1. Install a gutter system and ensure that storm water channels away from the home perimeter. Although it is not improper to delay storm water from entering storm drains (e.g. to use for rain gardens), it is important that these areas be some distance from perimeter walls. Do not allow water to stand against the perimeter walls.
2. Install low-sone bathroom exhaust fans in the bathroom with fan delay timers and duct these fans through the roof.
3. Install a kitchen range hood that ducts to the outside.
4. Provide a hatch cover to the attic entrance.
5. Seal penetrations where the ducts enter the attic with foam or caulking.
6. Trim the slab reinforcing mesh.
7. Install siding over the bottom plate.
8. Carefully regrade at the exterior so that at least eight inches of foundation wall show. Do not allow ground to rise to the wood bottom plate.
9. Monitor the home for evidence of groundwater ponding within the home during rainy periods.



Figure 5: Incomplete siding over bottom plate



Figure 6: Gap in bottom plate



Figure 7: Untrimmed slab reinforcing mesh

Inspection Number: 1-5
Address: 602 E. Virginia
Model Type: Ranch
Foundation: Slab on grade
Construction: Stucco over styrofoam
Heat Type: Heat Pump
Bedrooms: 3
Occupancy: 3
Age: Approximately 8-10 yrs



Figure 1: 602 E. Virginia

Mold and Moisture

Conditions: This structure originally housed the Boys and Girls Club and was later converted to residential use. The construction method was stucco applied over rigid Styrofoam panels. Concrete might be



Figure 2: Stucco deterioration around window



Figure 3: Close-up of stucco deterioration

within the Styrofoam providing the structural support, which would make the walls an ICF type (insulated concrete forms). Another wall type similar to the walls at this site is EIFS (Exterior Insulation and Finish System).

In both cases, the stucco provides an airtight finish, preventing indoor moisture from leaving the building and any moisture that does enter from leaving.

In this home, the stucco was deteriorating (Figures 2-4). Possibilities for the cause of the cracking included; freeze/thaw of moisture, other expansion/contraction of the stucco, or an unidentified installation defect. This allowed both moisture and cold air to enter the walls. The cracking had not progressed further due to the stress relief caused by the initial cracks. Simply sealing the cracks would probably lead to additional cracking.



Figure 4: Cracks in stucco

Mold was on the bottom of walls (Figure 5), at a wall and ceiling juncture (Figure 6),



Figure 5: Mold at bottom of walls



Figure 6: Mold at wall/ceiling juncture

in the middle of one wall (Figure 7), and on windowsills (Figure 8). Some of this mold was clearly a result of water penetration through the building envelope, such as the mold at the base of the walls. Other mold was more likely a result of high humidity levels indoors combined with low ventilation rates, such as the mold at the wall/ceiling juncture and the mold around the windows. When a thermal bridge, allows interior surfaces to be cold, condensation can result in mold growth. This can happen at windows, or if the Styrofoam insulation is incomplete or missing.



Figure 7: Mold in center of wall

Rainwater Management: The site was flat and there were no gutters. Water often was standing alongside the home after a rainfall event. It appeared concrete had been added at the back door to improve the grading and prevent ponding, although the flashing at this door was inadequate (Figure 9).



Figure 8: Mold at windowsill

Bathroom/Kitchen: The kitchen had a recirculating fan and there were no bathroom exhausts.

Attic: There was no attic or attic insulation, due to the construction method.

Heating System: The home was conditioned by a two and a half ton heat pump (electric forced air).

Occupant Notes: Two adults and one child lived in this home.

Recommendations:

On the exterior:

Two primary features; 1) what is the structural support for the home and 2) what is the structural detailing at the foundation/wall connection, must be determined before an extensive comprehensive repair strategy can be undertaken. If sheathing external to the foam provides the structural support, attach new siding over the existing finish and to the sheathing. If the structure is via concrete internal to the foam this repair method is not an option.



Figure 9: Added concrete, deficient flashing at back door

The foam should not contact the ground. In addition, some exposed slab should be at the base of the exterior walls. The stucco sheathing extended all the way to the ground at the time of assessment, so any contact between the foam and ground could not be determined. Remove the lower portion of the stucco to identify the structural details. If

the foam extends to the ground, this would be a likely source of the water that caused the mold at the base of the walls inside the home. If the foam did extend to the ground, and the foam is attached to an external sheathing, it may be possible to remove the lower portion of the foam to prevent the ground contact and to expose the slab. If the structure is concrete internal to the foam, this repair method may not be an option.

If support is provided by a wood frame or by sheathing, the wood should be inspected to assess any moisture-caused deterioration.

In addition, the flashing at the base of the back door should be improved to prevent water from entering under the door.

Gutters

1. Install a gutter system.
2. Ensure stormwater channels away from the perimeter of the home. Although it is not improper to delay stormwater from entering storm drains (e.g. use of rain gardens) it is important that these areas be some distance from perimeter walls. Water should not be allowed to stand against the perimeter walls of the homes.

Ventilation:

1. Install low-sone bathroom exhaust fans in the bathrooms that vent to the outside.
2. Ensure the fans are controlled with mechanical timers.
3. Install a kitchen exhaust fan that vents to the outside.

On the Interior:

1. Clean up the mold, after the causes of the mold are addressed. ATOHA should consider replacing the windows with better ones to eliminate the condensation on the windows.

Inspection Number: 1-6
Address: 216 W. Mississippi, Apt. A
Model Type: Townhouse
Foundation: Slab on grade
Construction: Structural Insulated Panels
Heat Type: Electric Heat Pump
Bedrooms: 2
Occupancy: 1
Age: 6 months

Mold and Moisture Conditions: No mold was found.

Rainwater Management: There were no gutters or downspouts. The ground at the rear of the home was still under construction, so it was not clear whether there would be grade problems.

Bathroom/Kitchen: The kitchen had electric appliances with no additional ventilation. The bathroom fan did not vent to the outside.

Attic: The attic was conditioned space due to the structural insulated panels (SIPs) forming the roof.

Heating System: A heat pump with ductwork in the attic heated the home. The HVAC system included an air-to-air heat exchanger, provided good ventilation (Figure 2).

Occupant Notes: One adult lived in the home.

Other: The siding was dirty from construction work (Figure 3).

Recommendations:

1. Install gutter and downspouts.
2. Carefully pressure-wash the construction dirt from the siding to prevent mold and mildew.
3. Vent the bathroom fan to the outside.
4. Install a kitchen range hood that vents to the outside.
5. Ensure that an air-to-air heat exchanger is fully installed and operating properly.
6. Ensure that the outside air intake of the air-to-air heat exchanger is not clogged with debris such as leaves. Also change and clean the filter of the air-to-air heat exchanger regularly.



Figure 1: 216 W. Mississippi, Apt. A



Figure 2: Air-to-air heat exchanger



Figure 3: Dirty siding